

Course guide

295327 - 295SE121 - Uses of Electrical Energy and Sustainability

Last modified: 17/06/2025

Unit in charge: Barcelona East School of Engineering
Teaching unit: 748 - FIS - Department of Physics.
717 - DEGD - Department of Engineering Graphics and Design.
709 - DEE - Department of Electrical Engineering.

Degree: MASTER'S DEGREE IN TECHNOLOGIES FOR DISTRIBUTED ENERGY SYSTEMS (Syllabus 2025). (Optional subject).

Academic year: 2025 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: Alcaraz Sendra, Olga

Others: Sureda Carbonell, Barbara
De La Hoz Casas, Jorge
Lazzarini, Boris
Alcaraz Sendra, Olga

TEACHING METHODOLOGY

Knowledge acquisition activities: theoretical lectures; readings; watching videos; creating diagrams, summaries, or concept maps.
Practice and application activities: problem-solving; analysis and discussion of cases and simulations.
Exploration and discovery activities: individual or group work, supported by the faculty through tutoring, using active learning methodologies.

LEARNING OBJECTIVES OF THE SUBJECT

The course aims to provide students with a deep and interdisciplinary understanding of sustainability principles applied to the energy sector, addressing their environmental, social and economic impacts. Students will explore tools and methodologies for assessing and monitoring energy sustainability, analyse key regulations such as the Corporate Sustainability Reporting Directive (CSRD) and the Corporate Sustainability Due Diligence Directive (CSDDD) in the European Union, and understand the functioning of carbon markets as a mechanism for the energy transition. In addition, the course will encourage reflection on the democratisation of the energy sector, with a special emphasis on initiatives such as energy communities and just transition, preparing students to apply these perspectives in the design and management of sustainable and distributed energy systems.

STUDY LOAD

Type	Hours	Percentage
Hours small group	21,0	14.00
Self study	108,0	72.00
Hours large group	21,0	14.00

Total learning time: 150 h

CONTENTS

TOPIC 1: Introduction to sustainability in the energy sector

Description:

1. Historical context and evolution of the energy sector: The evolution of energy consumption. Relationship between energy and human development.
2. Definition and principles of sustainability applied to energy: Definition of energy sustainability. Principles of efficiency, clean energy, social inclusion and equity, climate justice.
3. The energy sector and the major challenges of sustainability: The impacts of the energy sector. The challenges of sustainability. Technological and economic challenges. key actors in the energy sector.
4. The energy sector and the Sustainable Development Goals. SDG7: affordable and clean energy. Relationship with other SDGs.
5. Regulatory and Regulatory Framework. Global initiatives and the Paris Agreement. Energy transition policies. Challenges for governments.
6. Global trends in the energy transition.

Related activities:

- Activity 1. Evolution of the electricity mix in developed and developing countries.
Activity 2. Local vs. global issues.

Full-or-part-time: 21h

Theory classes: 3h

Laboratory classes: 3h

Self study : 15h

TOPIC 2: Environmental and social impacts of the energy sector

Description:

1. Environmental impacts of energy sources. Comparison between fossil, renewable and nuclear energies. Impacts on biodiversity, land use and water resources. Greenhouse gas (GHG) emissions and their contribution to climate change.
2. Social impacts: Energy poverty. Social impacts of mining critical materials. Social acceptance of energy infrastructures. Social conflicts associated with large energy projects.

Related activities:

- Activity 1. Analysis of the European Pollutant Release and Transfer Register.
Activity 2. Environmental and social impacts of the development of lithium for batteries vs. nuclear energy as a transitional technology.

Full-or-part-time: 21h

Theory classes: 3h

Practical classes: 3h

Self study : 15h

TOPIC 3: Assessment and monitoring of energy sustainability

Description:

1. Sustainability indicators. Carbon intensity, emissions intensity, energy intensity, renewables percentage.
2. Tools and frameworks for assessing sustainability. Life cycle analysis. ESG standards (environmental, social, governance).
3. Energy audits and certifications

Related activities:

- Activity 1. Design of a system of energy sustainability indicators to evaluate the sustainability of different previously assigned projects.

Full-or-part-time: 21h

Theory classes: 3h

Practical classes: 3h

Self study : 15h

TOPIC 4: Sustainability regulations and corporate responsibility in the EU: CSRD and CSDDD.

Description:

1. Introduction to European sustainability legislation: The "European Green Deal" as a roadmap towards climate neutrality.
2. The Corporate Sustainability Reporting Directive (CSRD). Objectives. Scope. Information required. Assessment of material sustainability risks and impacts.
3. The Corporate Sustainability Due Diligence Directive (CSDDD). Objectives. Scope. Key requirements. Impact on the energy sector.
4. Connections with other frameworks and initiatives. EU taxonomy. ESG principles. Relationship with sustainable investments and green financial markets. Alignment with the UN Guiding Principles on Business and Human Rights. Connection with the Sustainable Development Goals (SDGs).
5. Impacts of European regulatory frameworks on citizens.

Related activities:

Activity 1. Critical analysis of a sustainability report of an energy company: Review compliance with the requirements of the CSRD.

Activity 2. Simulation of the implementation of the CSDDD: Develop a due diligence plan for a fictitious company in the energy sector.

Full-or-part-time: 24h

Theory classes: 3h

Practical classes: 3h

Self study : 18h

TOPIC 5. Accounting methodologies for greenhouse gas emissions (GHG) applied to the company.

Description:

1. Introducció a la comptabilitat d'emissions de GEH.
2. Principals metodologies i marcs de referència. El Green House Gas Protocol (GHGP). La ISO 14064. La Science-Based Target Initiative (SBTi) i la seva aplicació al sector energètic.
3. Mètodes de càlcul d'emissions. Metodologies directes i indirectes.
4. Estudis de cas i exemples pràctics.

Related activities:

Activity 1. Calculation of the corporate carbon footprint.

Full-or-part-time: 21h

Theory classes: 3h

Practical classes: 3h

Self study : 15h

TOPIC 6. Carbon markets and their relationship with energy sustainability.

Description:

1. Introduction to carbon markets. Concept and objectives.
2. Emissions offsetting and avoided emissions.
3. Carbon markets at the international level. Articles 6.2 and 6.4 of the Paris Agreement.
4. Carbon markets in the European Union. The EU Emissions Trading System (EU ETS)
5. Voluntary carbon markets and how companies outside the regulatory framework can contribute to decarbonization.
6. Carbon border adjustment mechanisms (CBAM) and their potential impact on the energy sector.
7. Benefits and limitations of carbon markets.

Related activities:

Activity 1. Case study. Analysis of a project certified under Article 6.4 of the Paris Agreement.

Estimate avoided emissions and discuss their validity.

Activity 2. Modeling the functioning of a carbon market

Full-or-part-time: 21h

Theory classes: 3h

Practical classes: 3h

Self study : 15h

TOPIC 7. Future prospects and democratization of the energy sector

Description:

1. Technological innovations and global trends for energy sustainability. Green hydrogen as an energy vector. Distributed energy systems. The challenge of mass electrification. Smart and sustainable cities. Carbon capture and storage systems.
2. Democratization of energy: energy communities. Definition. Typologies. Benefits.
3. Social innovation and inclusion in the energy transition. Just transition. Citizen participation in energy planning.
4. Projects and initiatives on a global and European scale.

Related activities:

Activity 1. We will visit the energy community of La Bordeta in BCN and meet with technicians from its driving group.

Full-or-part-time: 21h

Theory classes: 3h

Practical classes: 3h

Self study : 15h

GRADING SYSTEM

Final exam: 30%

Evaluation of activities carried out in class: 60%

Attendance and participation in class: 10%

BIBLIOGRAPHY

Basic:

- MacKay, D. J. C.. Sustainable Energy – Without the Hot Air [on line]. Cambridge: UIT Cambridge Ltd, 2009 [Consultation: 17/06/2025]. Available on: <https://www.withouthotair.com/>. ISBN 978-0-9544529-3-3.
- International Energy Agency (IEA). World Energy Outlook 2024 [on line]. 2024 [Consultation: 17/06/2025]. Available on: <https://www.iea.org/reports/world-energy-outlook-2024>.
- International Renewable Energy Agency (IRENA). Renewable power generation costs in 2022 [on line]. Abu Dhabi, 2023 [Consultation: 17/06/2025]. Available on: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2023/Aug/IRENA_Renewable_power_generation_costs_in_2022.pdf. ISBN 978-92-9260-544-5.
- Siddharth Sareen (Editor). Enabling Sustainable Energy Transitions [on line]. Switzerland: Palgrave Macmillan, 2020 [Consultation: 17/06/2025]. Available on: <https://library.oapen.org/bitstream/id/01fdfccb-91f9-4bf6-bd9b-f13dbbf03dee/1007309.pdf>. ISBN 978-3-030-26890-9.
- Dustin Mulvaney. Sustainable Energy Transitions. Socio-Ecological Dimensions of Decarbonization. Palgrave Macmillan, 2020. ISBN 978-3-030-48912-0.

Complementary:

- Aleh Cherp, Vadim Vinichenko , Jessica Jewell , Elina Brutschin, Benjamin Sovacool. "Integrating techno-economic, socio-technical and political perspectives on national energy transitions: A meta-theoretical framework". Energy Research & Social Science.
- Intergovernmental Panel on Climate Change (IPCC). Summary for Policymakers. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [on line]. Cambridge, UK and New York, NY, USA. : Cambridge University Press, 2022 [Consultation: 17/06/2025]. Available on: <https://www.ipcc.ch/report/ar6/wg3/chapter/summary-for-policymakers/>.
- United Nations Environment Programme. . Emissions Gap Report 2024: No more hot air ... please! With a massive gap between rhetoric and reality, countries draft new climate commitments. [on line]. Nairobi, 2024 [Consultation: 17/06/2025]. Available on: <https://www.unep.org/resources/emissions-gap-report-2024>. ISBN 978-92-807-4185-8.

RESOURCES

Other resources:

"Fit for 55" Package (2021). https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541 />"The European Green Deal" (2019). https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en />CSRD (Corporate Sustainability Reporting Directive): https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en />CSDDD (Corporate Sustainability Due Diligence Directive): https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en />EU Emissions Trading System (EU ETS): https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets_en />Greenhouse gas protocol: <https://ghgprotocol.org/> />SBTi: Guidance for Science-Based Targets in the Energy Sector. <https://sciencebasedtargets.org> />Global carbon Atlas: <https://globalcarbonatlas.org/> />Open LCA: <https://www.openlca.org/> />Carbon Disclosure Project (CDP). Platform for emissions and sustainability reporting. <https://www.cdp.net/en> />Calliope: Open source tool for modeling sustainable energy systems. <https://www.callio.pe/>